

Integrated Navigation on Vehicle Based on Low Cost MEMS SINS/GNSS using LS-SVM

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Research Article

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Abstract

The high-precision initial alignment time for the MEMS SINS/GNSS combination system is too long, and it is difficult to ensure the flexible navigation of existing low-cost vehicles. A LS-SVM-assisted fast alignment method is proposed, which uses MEMS gyroscopes, accelerometers and dual-antenna satellite receivers to achieve fast alignment under MEMS SINS/GNSS. Based on the analysis of traditional coordinates and strapdown inertial navigation, the dynamic error model is given. The self-aligned frame of LS-SVM is proposed. At the same time, the EKF filter for training is designed and the motion characteristics of the car body are selected. The state equations and observations, using the EKF to train the LS-SVM model, ultimately achieve fast alignment. Finally, the proposed method is simulated and tested. The final attitude alignment accuracy is better than 0.2° and the alignment time is 10s. Compared with the EKF alignment method under the traditional direct transfer alignment, the alignment accuracy and the alignment time are significantly improved, which can meet the requirements of low-cost vehicle flexibility.

Full Text

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Figures

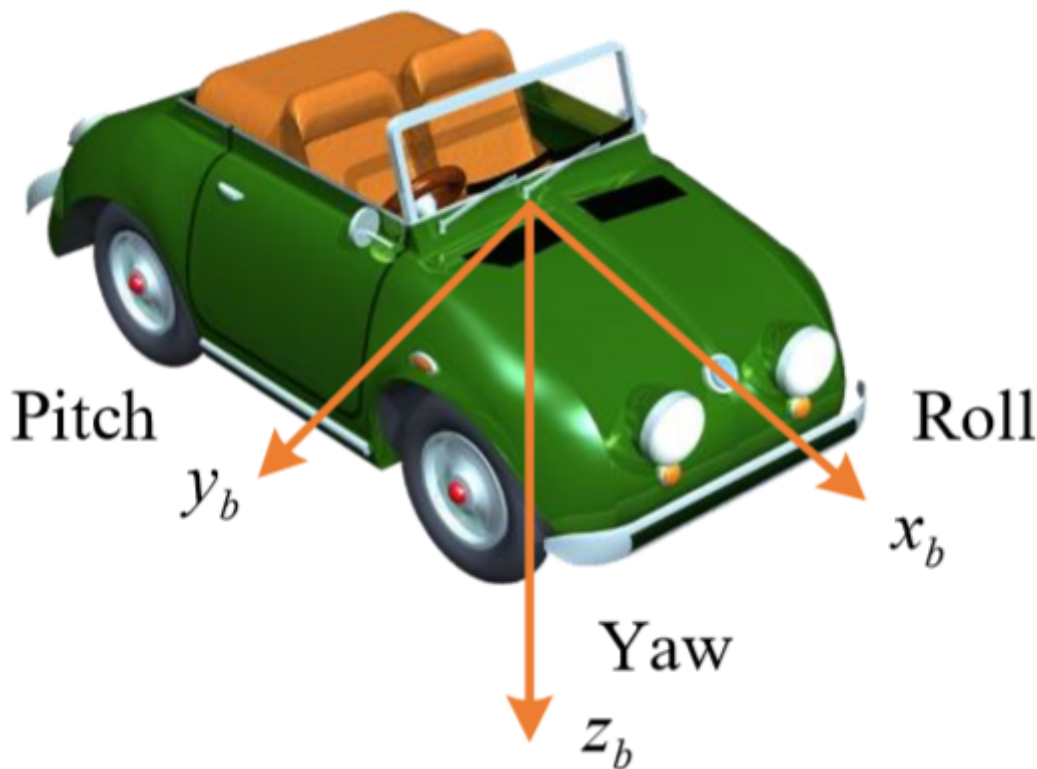


Figure 1

Carrier coordinate system definition

Fig.2.

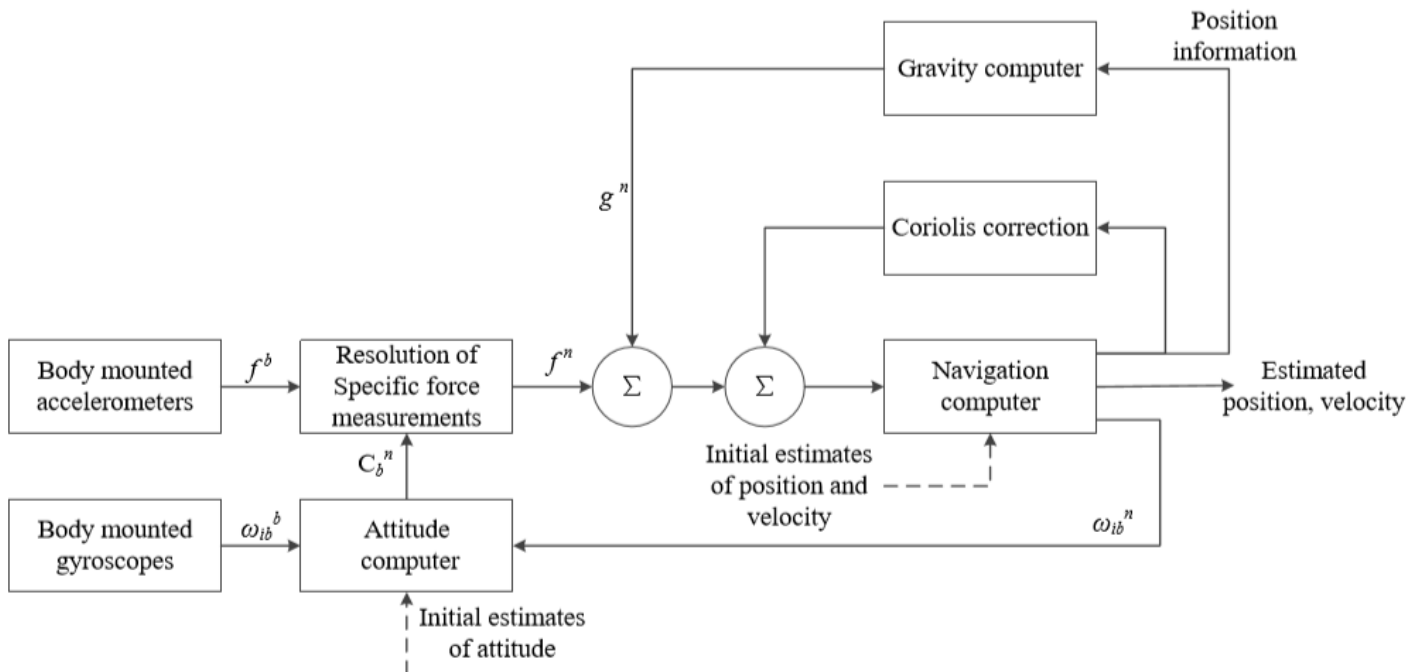


Figure 2

Strapdown inertial navigation system's mechanical arrangement

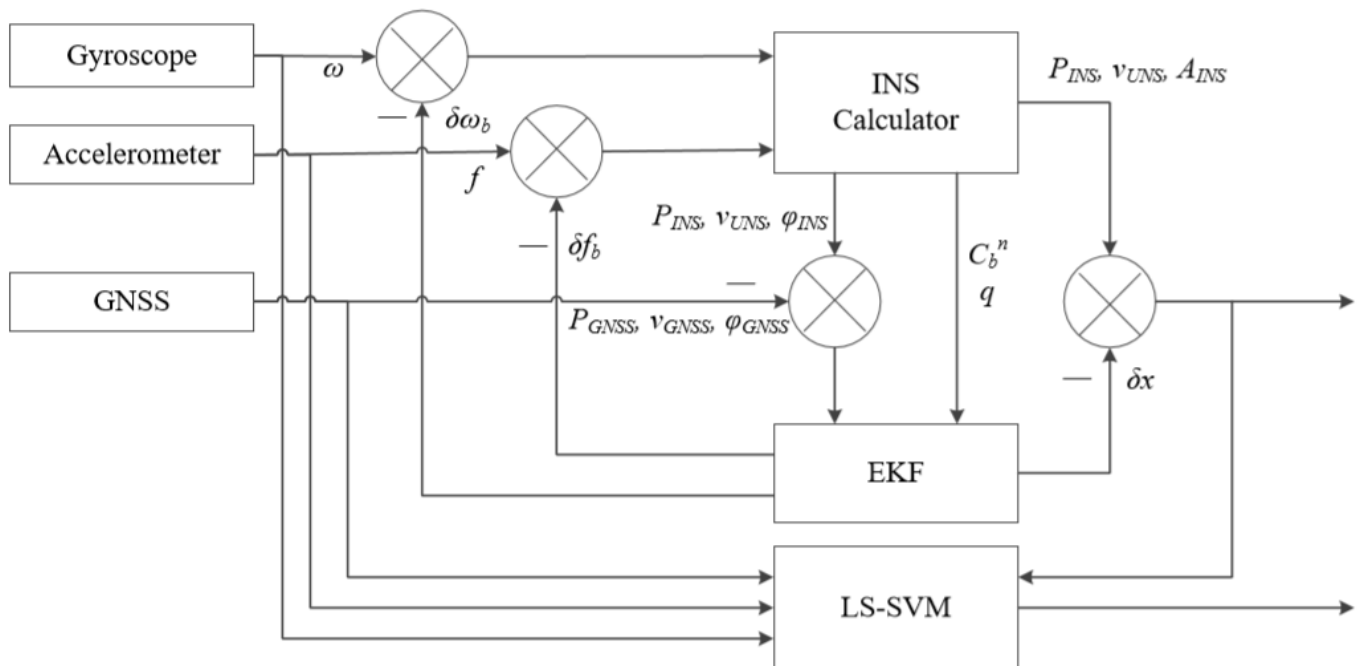


Figure 3

Initial alignment's work principle

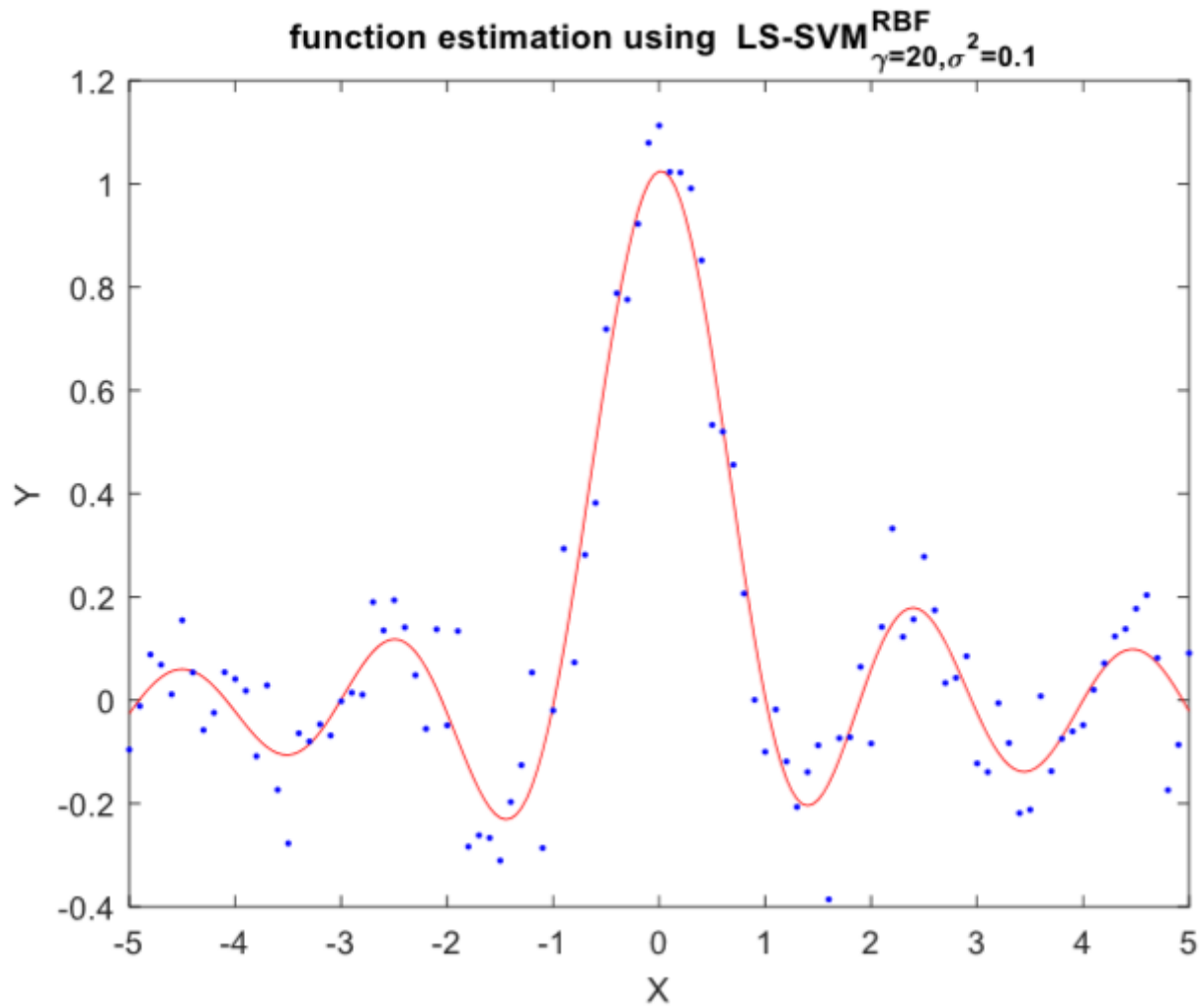


Figure 4

Simple regression problem. The solid line indicates the estimated outputs, the dotted line represents the true underlying function. The stars indicate the training data points. Using the open dataset to test the classifier of LS-SVM. As can be seen from the results, LS-SVM can effectively classify random data.

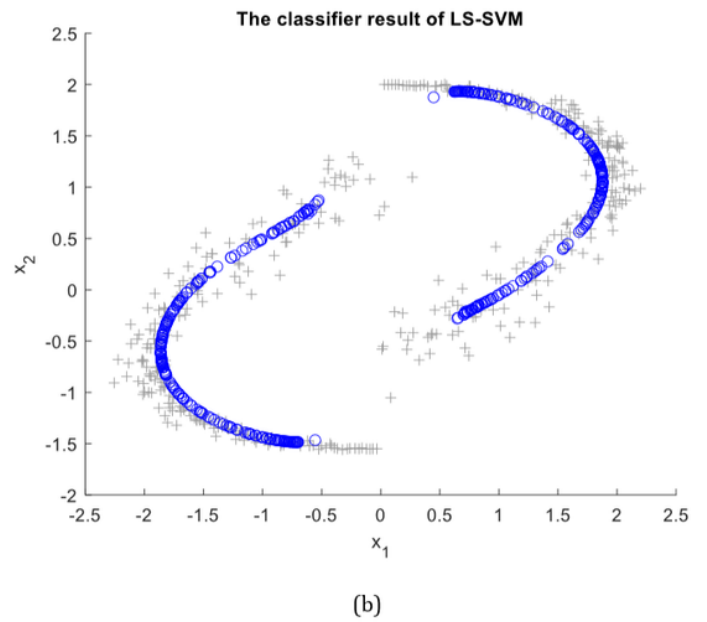
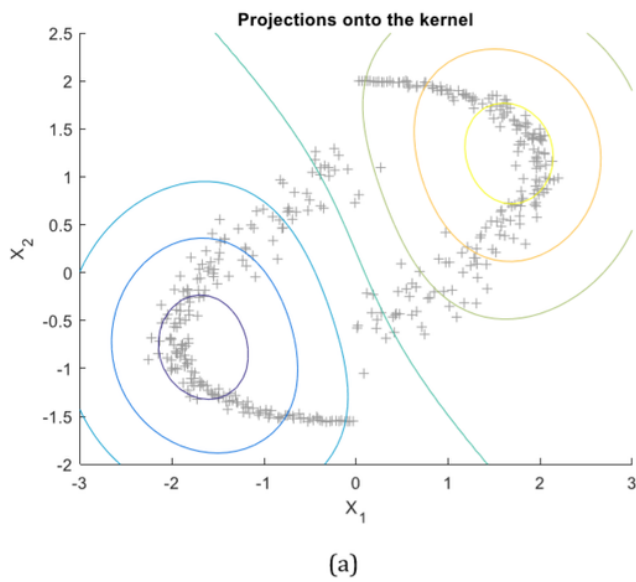


Figure 5

De-noised data ('o') obtained by reconstructing the data-points ('+') using LS-SVM.

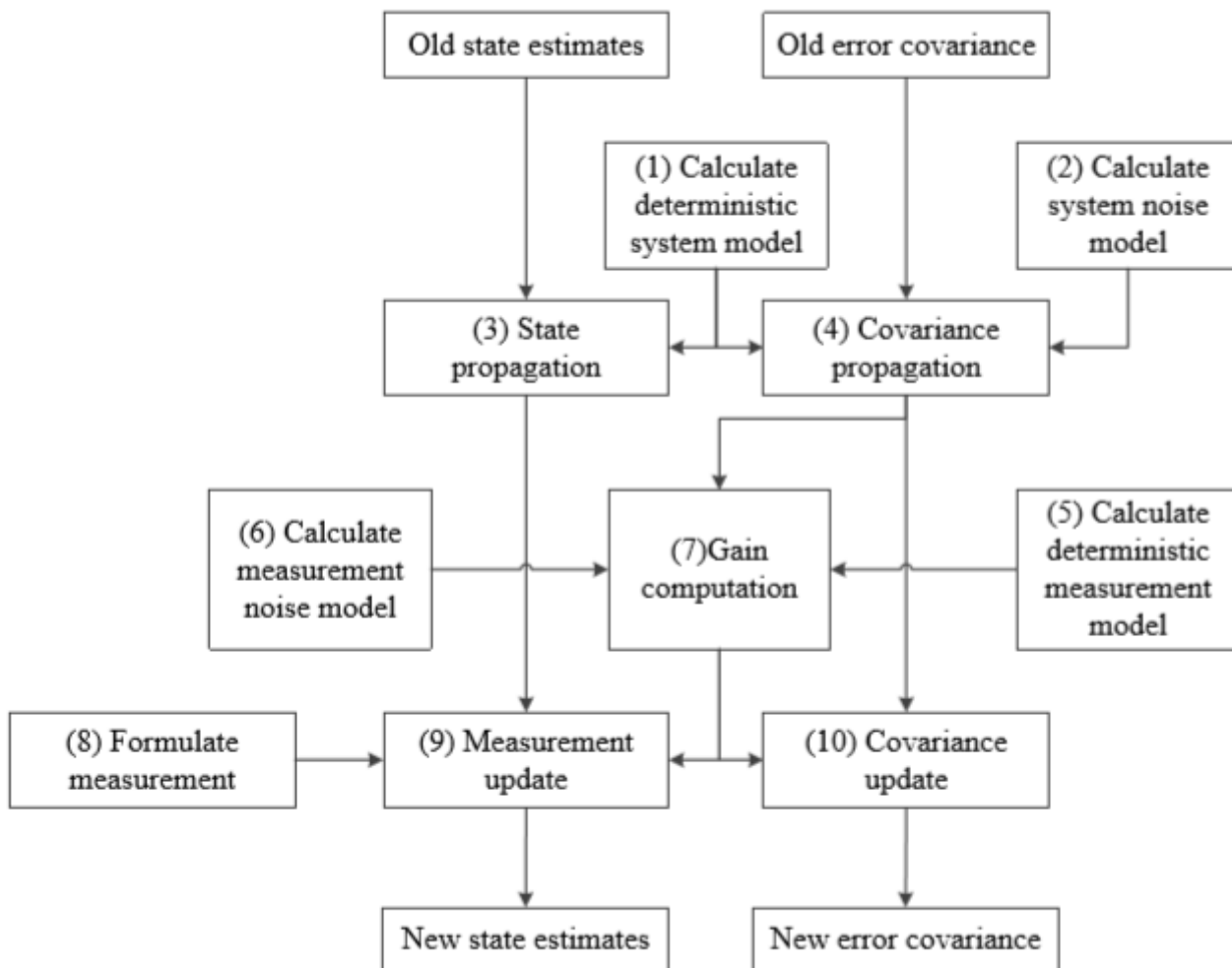


Figure 6

Flow diagram of EKF algorithm

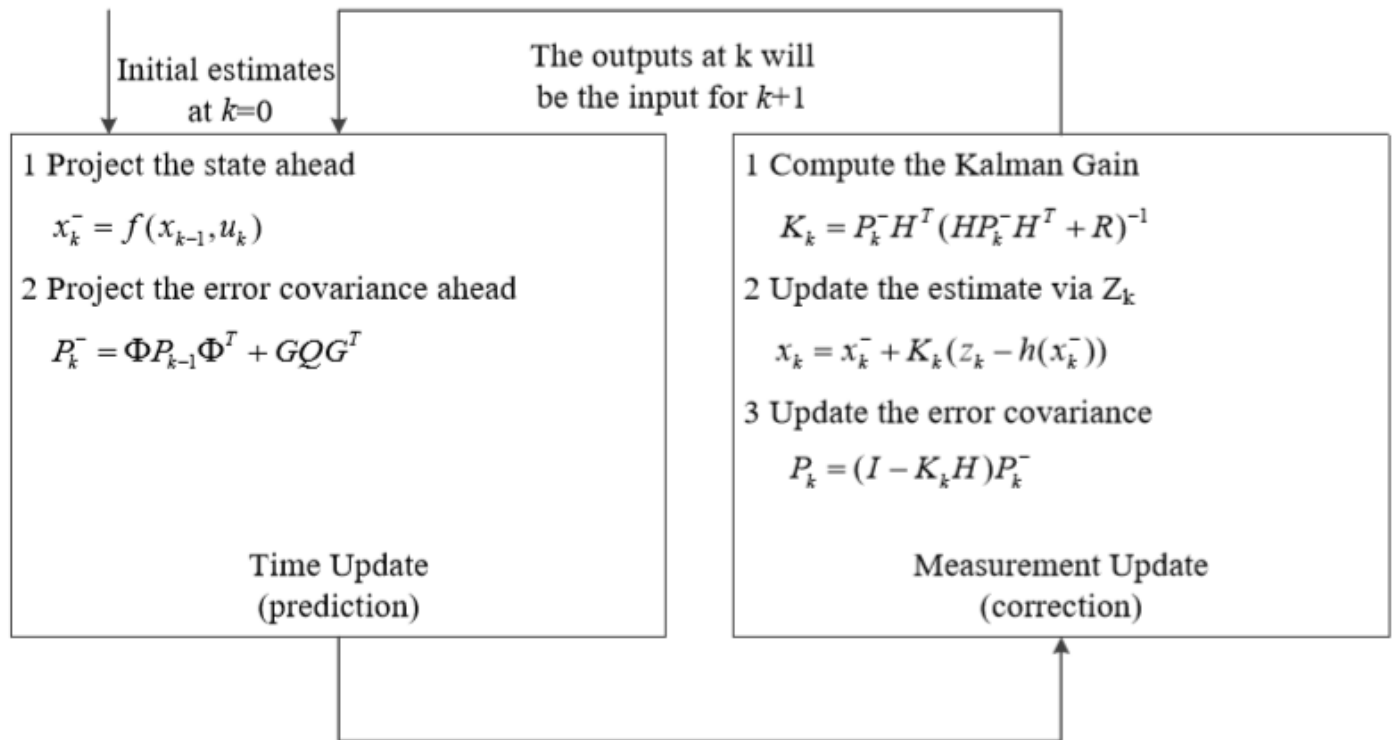


Figure 7

EKF update process

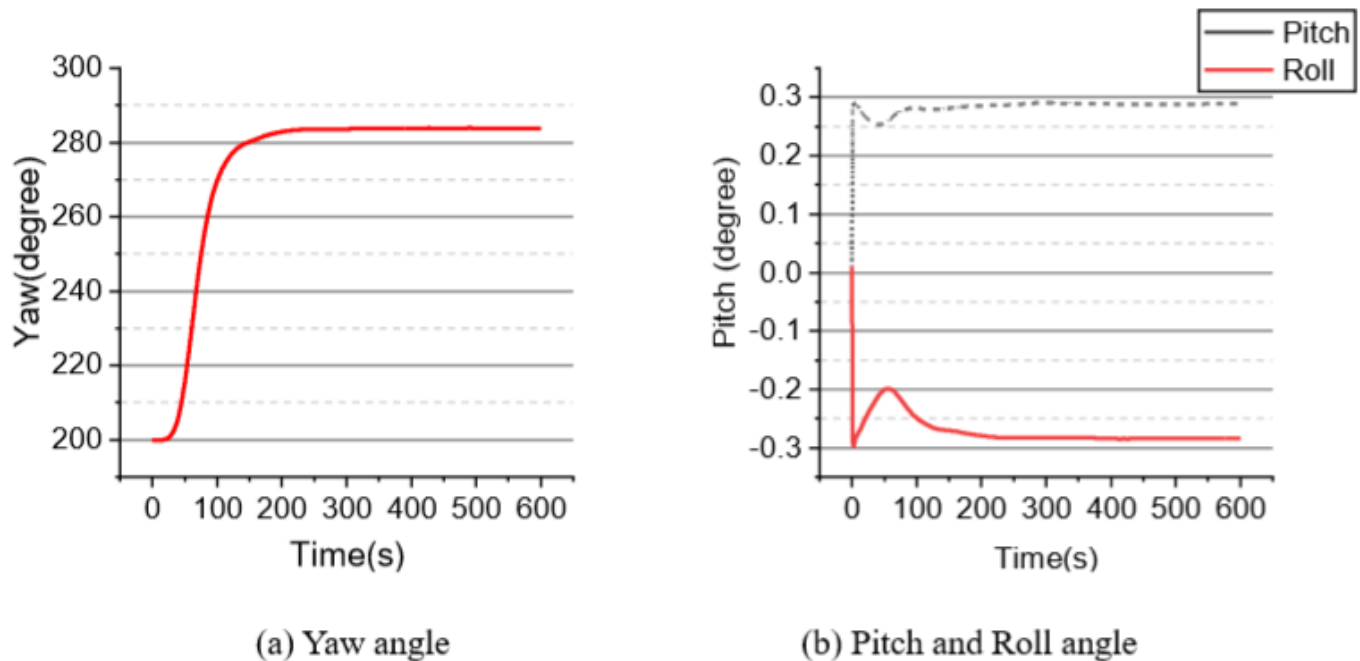


Figure 8

EKF simulation results

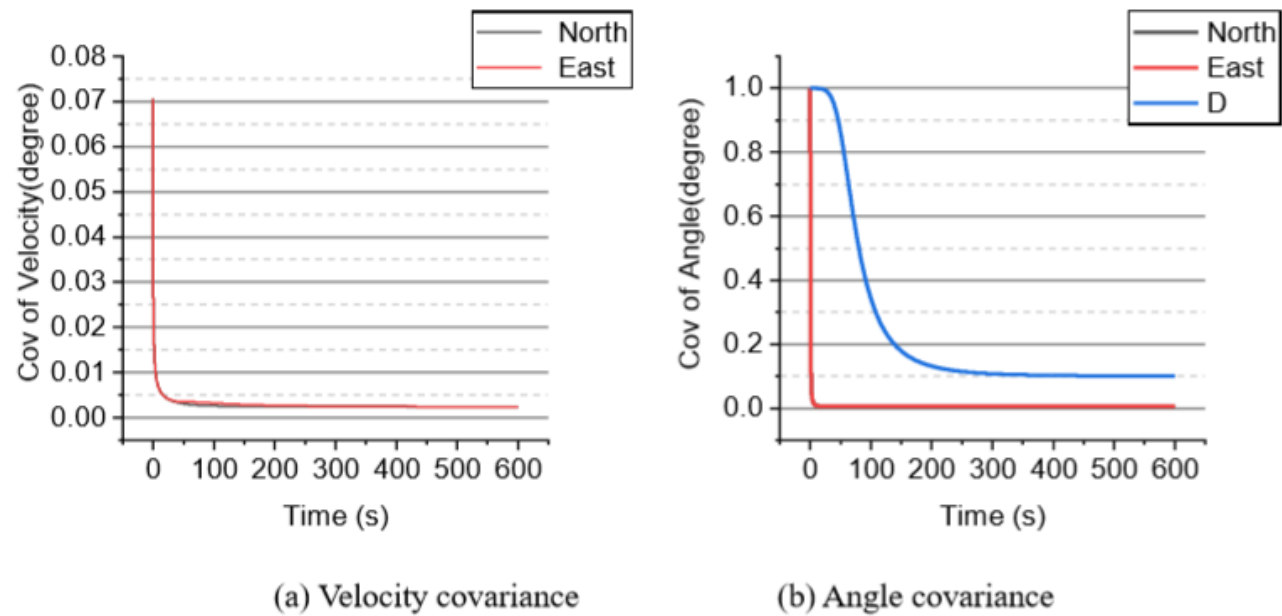


Figure 9

Covariance results of state variables

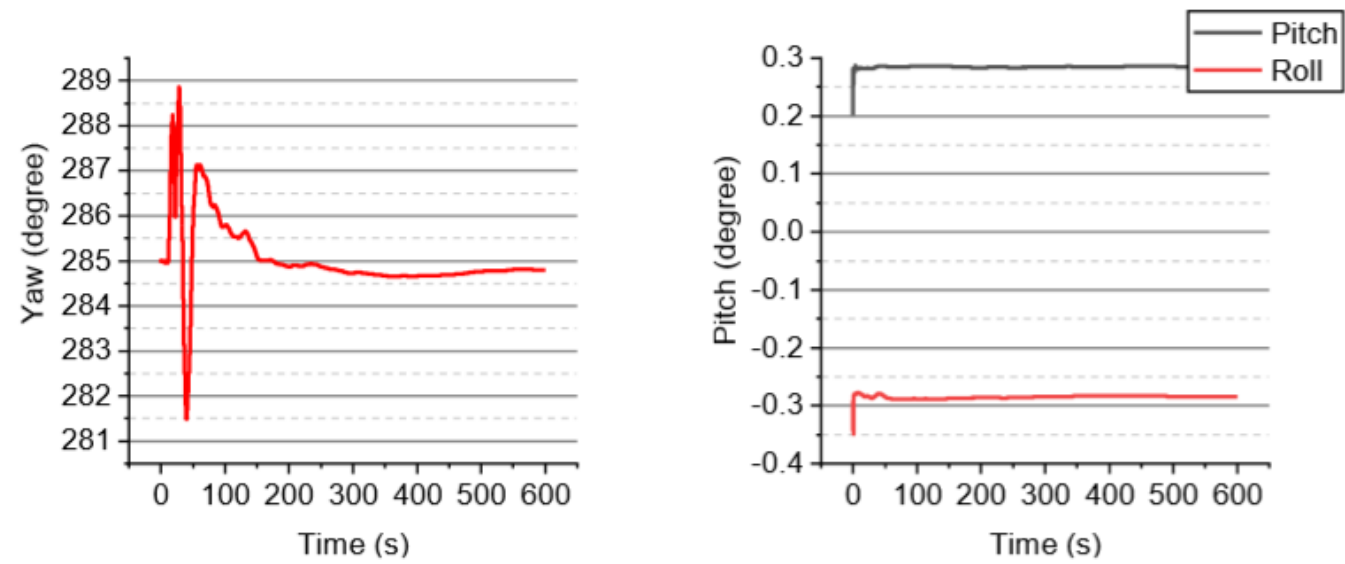


Figure 10

LS-SVM resolving results

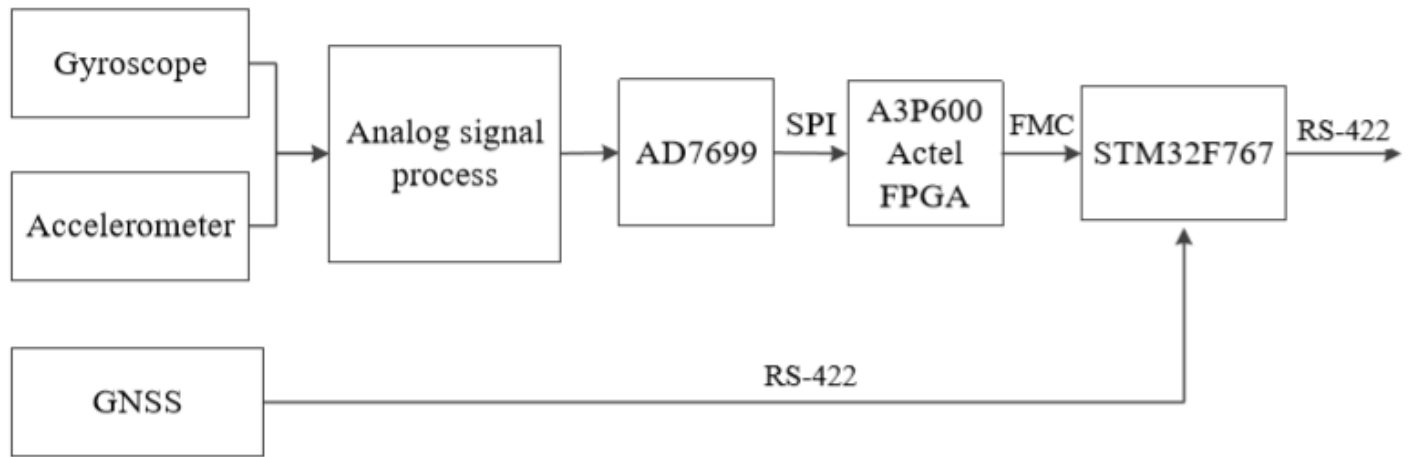


Figure 11

Hardware architecture diagram



Figure 12

Hardware photo



Figure 13

Car for running

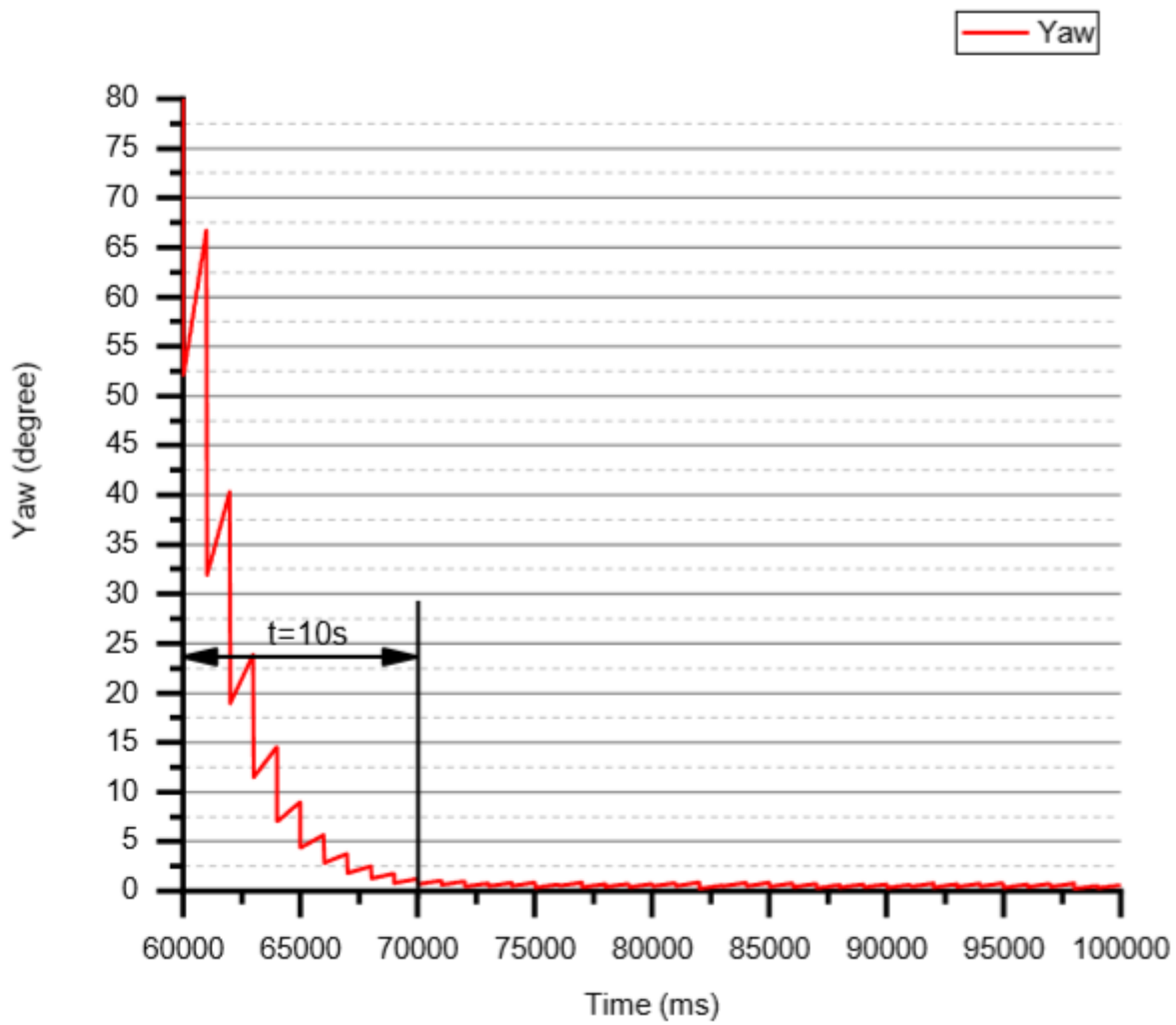


Figure 14

Yaw angle output

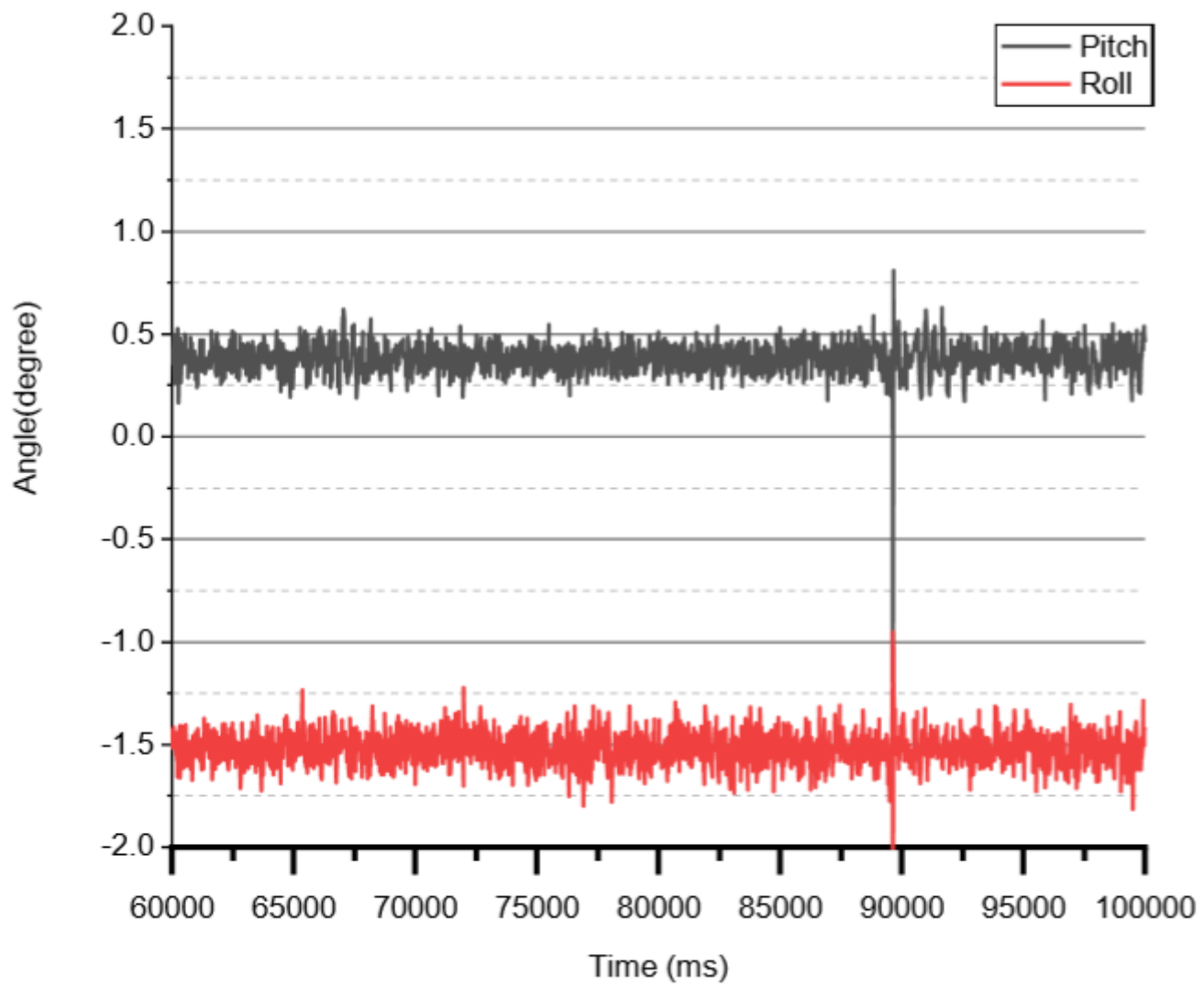


Figure 15

Pitch and roll angle output

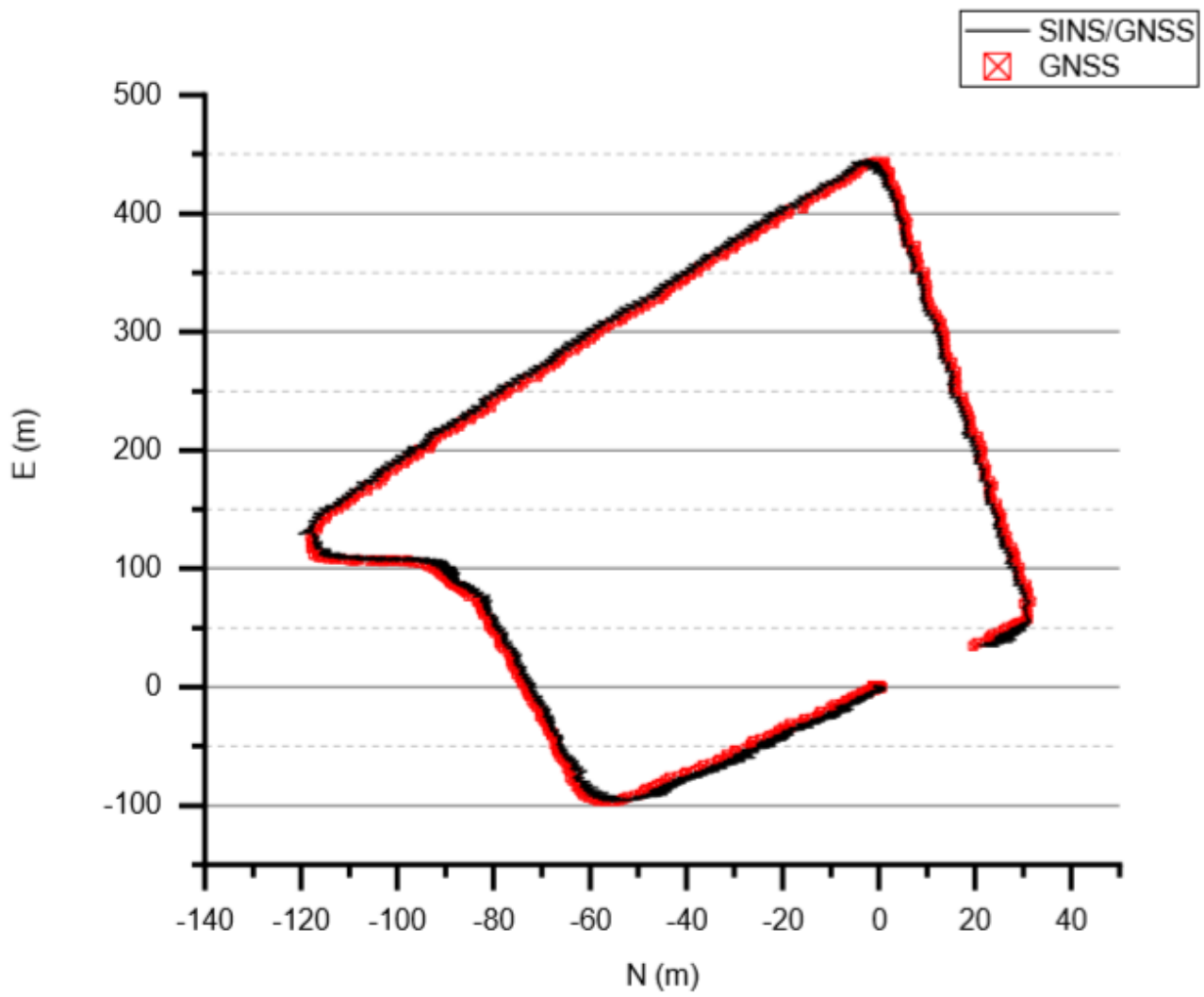
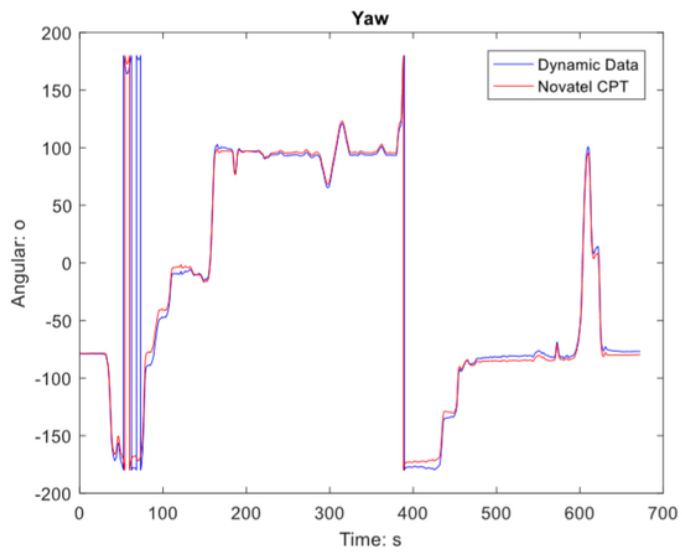
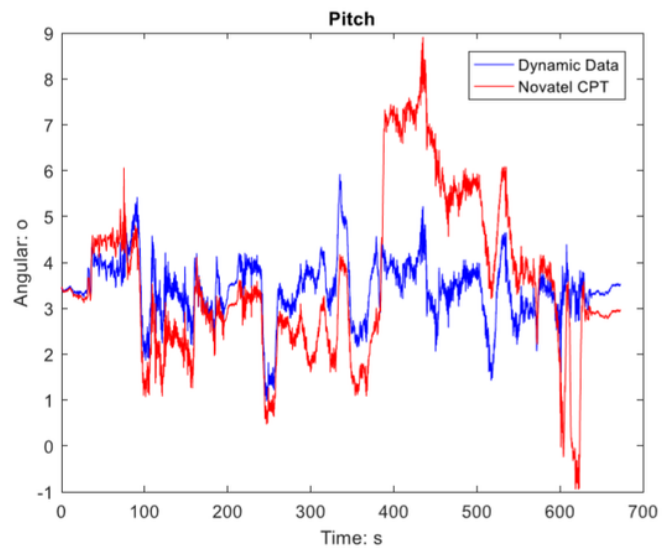


Figure 16

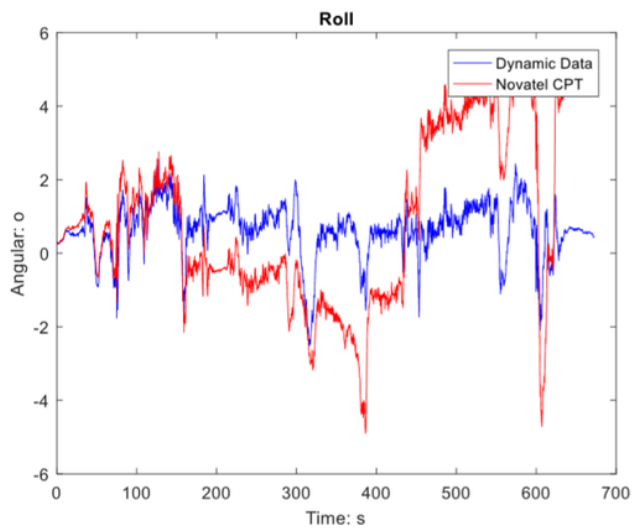
Position output with integrated device



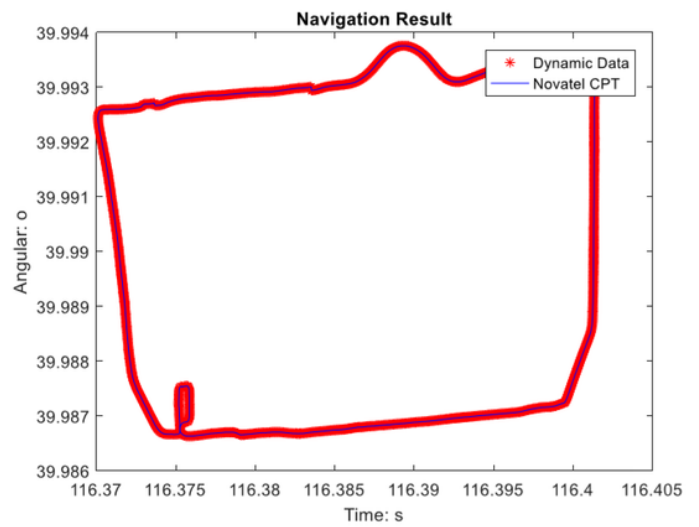
(a) the yaw result



(b) the pitch result



(c) the roll result



(d) the navigation result

Figure 17

The navigation result compares with Novatel CPT.